White Clover - How Much And How To Get It

S L Harris
Dairying Research Corporation
Hamilton

Summary

- White clover provides a cheap source of nitrogen, has high nutritive value, improves forage intake and utilisation rates of cows, increases milk production especially in summer-autumn, and complements perennial ryegrass growth patterns. Clover is estimated to be worth $380 - $435/ha/y on an average dairy farm.
- Clover content of dairy pastures (15-20%) is lower than the 50-70% needed for maximum milksolids production.
- A number of factors affect clover growth and persistence in dairy pastures, including climate, soil N levels, N fertiliser use, soil fertility, companion species, cultivar choice, pasture establishment, grazing management, and pests and diseases.
- While it is possible to increase clover levels to at least 50% in the short-term, it is very difficult to maintain a high clover content in a mixed pasture, since clover levels decrease over time and a natural ryegrass-clover balance is reached.
- Options which may result in larger, longer-term increases in clover content are either difficult to achieve, have not been tested in a dairy farm system to determine practical and economic viability, or require further research.

Why Bother With White Clover?

White clover (*Trifolium repens*) is a key factor in the international competitive advantage of New Zealand pastoral agriculture which is reliant on an inexpensive, high quality feed source. In dairy pastures white clover provides a cheap source of nitrogen, (N) has high nutritive value, improves forage intake and utilisation rates of cows, and complements perennial ryegrass growth patterns. It is also considered to be environmentally friendly and therefore contributes to our “clean green” image.

Although it is difficult to measure the value of white clover on a dairy farm, the calculation below can be used to form a very approximate estimate of clover’s worth in dollar terms:

Estimate of the value of white clover on a typical Waikato/Bay of Plenty dairy farm (stocking rate 2.75 cows/ha, 223 day lactation, average clover content 15-20%)

N fixation:
- *assume 140 - 200 kg N fixed/ha/y*
- *assume N fertiliser (urea) cost = $450/tonne*

→ *cost if had to replace N fixation with N fertiliser = $125 - $180/ha/y*

Milksolids production:
- *assume summer-autumn milksolids production if no clover = 0.94 kg MS/cow/d*
- *assume summer-autumn milksolids production if 20% clover = 1.18 kg MS/cow/d*
- *calculation for December 1 to end of lactation*
- *assume $3.50/kg milksolids payout*

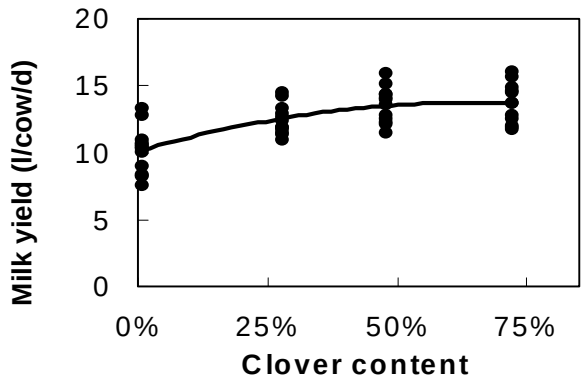
→ *value of white clover for increased milksolids production = $255/ha/y*

→ ***Total value of white clover = $380 - $435/ha/y**.*

Studies in Victoria, Australia (Rogers *et al.* 1982) and at the Taranaki Agricultural Research Station (Johnson and Thomson 1996) clearly demonstrated the benefits of white clover for milk production. The increased milk yield, compared with cows grazing perennial ryegrass, was due to both feed quality and quantity. White clover has a high nutritive value compared with grasses, due to lower levels of structural carbohydrate, higher metabolisable energy levels, higher digestible protein and a faster rate of passage through the rumen (Ulyatt 1981). Under white clover grazing, bacterial populations in the rumen make more efficient use of proteins and amino acids (Thomson 1984). Voluntary herbage intakes (kg DM/cow/d) of cows grazing pure clover are also greater than intakes of cows grazing ryegrass (Rogers *et al.* 1982).

Most benefit from high clover content in dairy pastures occurs after peak lactation. The comparatively high quality of ryegrass during spring, associated with its high growth rate, makes benefits from increased clover content unlikely during spring. However in summer, clover is able to maintain its high nutritive value in contrast to ryegrass (Thomson 1984), Clover contents in dairy pastures over summer are also higher (Harris 1994).

Figure 1: Effect of clover content in a perennial ryegrass - white clover pasture on milk production in February 1996.



Is There an Optimum Clover content for Dairy Pastures?

Research at the DRC has indicated the optimum clover content of dairy pastures for maximum milk production over summer-autumn is 50-70% (% of total dry matter), not 100% clover. (Figure 1) (Harris *et al.* 1997a). The optimum clover content in dairy pastures for maximum pasture growth is more difficult to determine. From an agronomic viewpoint of balancing N inputs from clover with herbage bulk as offered by grasses, a clover content of at least 30-50% has been suggested (Martin 1960).

How Much White Clover is in Dairy Pastures?

Average clover content at No 2 Dairy, Ruakura, during 1993-96 was 16% of total annual DM production (16.2 t/ha) on a farmlet stocked at 3.2 cows/ha and which received maintenance fertiliser but no N fertiliser. There was considerable variation in clover content both between years and at different times of the year, with levels ranging from 7% in winter-early spring, to 33% in late summer-autumn. Levels of clover on commercial dairy farms in the Waikato-Bay of Plenty are similar and show the same variation between and within seasons.

There is a general view among dairy farmers that clover content has declined over the last 15-20 years. Although there has been no long-term monitoring of clover content on dairy farms, data from various trials conducted at DRC over the past 17 years do show a decline in average clover content (Table 2). Although there has been a small decline in clover content it may not be as great as suggested by visual observation. The decline in clover % has been a result of increased total pasture production because of improved ryegrass vigour and management options that favour grass growth. However, there has been no decline in actual clover yield (kg DM/ha).

Table 1: Clover content (% total DM) during different seasons and average annual clover yield from trials conducted at DRC. Data from Thom *et al.* (1986), L'Huillier (1987), Harris and Clark (1996) and Harris (unpubl.).

		Thom *et al.* 1980-1981	L'Huillier 1984-1985	Harris 1993-1996
% clover content	winter	20	19	9
	spring	24	18	13
	summer	25	28	24
	autumn	27	24	27
Average clover yield (kg DM/ha)		2545	2990	2590

Why is it Difficult to Get a High Clover Content?

Despite being a desirable component of New Zealand dairy pastures, white clover levels in pastures can, however, be unreliable and unsatisfactory, such that N inputs from white clover are insufficient to obtain maximum grass growth and animal production.

Mixed pastures have the ability to self regulate the N-cycle. It is this response to soil N levels which is the main factor determining ryegrass and clover contents in a mixed pasture (Schwinning and Parsons 1996). Clover has the advantage at low soil N levels because it fixes N. Ryegrass has the advantage at high soil N because of its more efficient uptake of mineral N and greater competitive ability for carbon fixation. During periods of clover growth, clover increases soil N levels and stimulates grass growth. However, during periods of grass dominance, grass will draw down soil N levels. This cycle of grass-clover growth makes it difficult to increase the clover content since exploitation of clover N fixation by grass leads to at least as much increase in ryegrass levels as in clover levels. This cycle, together with numerous other factors affecting clover growth, makes it very difficult to establish, and particularly maintain, high clover contents in pastures without resorting to impractical and uneconomic managements. It is possible to increase clover levels to at least 50% in the short-term, e.g. by establishing new pasture after several years of maize using a high clover seed rate (5 kg/ha). However, it is very difficult to maintain a high clover content in a mixed pasture since clover levels decrease over time and a ryegrass-clover balance is reached. Dairy farmers can, however, maintain clover levels and possibly achieve small increases in clover content by helping to increase clover's competitive ability.

Increasing Clover Content in Dairy Pastures

A number of factors affect clover content in dairy pastures. Addressing these factors while still maintaining a profitable farm system is the key to maintaining or achieving small increases in clover levels in pastures.

Nitrogen

Maximum gross margins per ha and a high level of milksolids production per ha and per cow are best achieved by combining N inputs from white clover and N fertiliser (Clark and Harris 1996). Clover content can be maintained at 15-20% even when applying up to 200 kg N/ha/y, provided the pasture grown is fully utilised, particularly in spring (Harris and Clark 1996). Applying the N as split dressings of less than 50 kg N/ha is recommended so that the effect on clover is reduced.

Soil fertility

White clover is a poor competitor for phosphate, sulphate and potassium, compared with grasses. Without adequate levels of P, K and S, white clover yield and persistence is jeopardised. The ideal levels for intensive dairying are 25-30 Olsen

P, 8-10 K and 8-10 S (Roberts *et al.* 1991). Lime is important for successful establishment of clover on soils where pH is below optimum (pH 5.5). Lime also promotes nodulation, better use of P, and increased molybdenum availability which is essential for N fixation in clover (Edmeades *et al.* 1984).

Companion species

Grass species have different competitive abilities with white clover which can influence clover content of pasture. Perennial ryegrass and tall fescue are more compatible than cocksfoot, Yorkshire fog, and many of the subtropical grasses such as kikuyu. Even with ryegrass it has been demonstrated that when tiller numbers exceed 5000/m^2, white clover content is decreased (Brereton *et al.* 1985). N fertiliser can increase ryegrass tiller density and therefore reduce clover content.

Clover cultivar choice

There is now a range of white clover cultivars available to New Zealand dairy farmers for use in pasture renovation. Larger leaved types such as Grasslands Kopu, Aran, Grasslands Challenge, Grasslands Sustain, Le Bons and Grasslands Pitau, should result in higher clover contents than medium and small leaved types. In a four year white clover cultivar trial at DRC, Challenge, Pitau, Sustain and a breeding line, G. 49 x Crau, yielded the best in mixed pasture. However, neither Challenge nor Pitau persisted well in the fourth year. Cultivars with excellent winter growth include Challenge, Kopu and Pitau, and those with good summer growth include Aran and Sustain (Caradus *et al.* 1996).

Clover establishment

Care taken during establishment of new pastures will be rewarded with a high clover content for at least the first two years after sowing. Full cultivation provides the best seedbed for clover establishment, but at a higher cost than drilling clover into permanent pasture. Weeds should be removed before renewal by either spraying before drilling, or by spraying before cultivation. Soil drainage or fertility problems should be remedied before final cultivation, while cultivation will help reduce soil compaction problems. A level, fine, firm seed bed should be prepared if cultivating. Seed is best sown using a 'V-ring' roller drill and lightly covered with chain harrows and then rolling again (except on strong clay soils prone to caking). Clover seed should be sown no deeper than 10-15mm - this is particularly difficult if drilling clover seed into existing pasture. Burial of clover seed at too great a depth, especially when clover is sown in combination with ryegrass, is the main cause of poor clover establishment. A higher clover content can be achieved by using a higher seed rate, e.g. 5 kg/ha instead of 3 kg/ha. However, the resulting increased clover content is short-lived, making the profitability of this questionable. It is not known whether inoculation of clover seed improves performance or persistence. It is best, therefore, to use bare seed or to inoculate within 12 hours of sowing. Annual broadcasting of additional clover seed into established pasture, often in combination with autumn fertiliser application, may sometimes boost clover content (Sheldrick *et al.* 1995).

Grazing management

Attaining a stable composition of white clover in pasture is affected by the preference grazing animals, including dairy cows, show for clover. When offered both pure clover and pure ryegrass, animals prefer a mixed diet of about 70% white clover : 30% ryegrass (Penning *et al.* 1995). However, this level of preference is unlikely to be achieved by cows grazing a typical mixed pasture since selection is largely restricted to clover patches in the sward which have a higher clover content than the pasture average, rather than at the level of fine discrimination between interspersed pasture species. While selection of white clover by grazing cows may reduce clover content, it is also desirable so that the nutritional benefits of clover can be maximised.

Although studies have shown total herbage production from grass/clover swards increased as defoliation interval was lengthened, overall clover content was not generally increased (Frame and Newbould 1984). At certain times of the year, however, shortening or lengthening grazing interval may increase clover content. For example, L'Huillier (1987) showed rotation length over winter had no effect on clover content, but short spring rotations (8 days) resulted in higher clover contents (36% vs 18%) than longer rotations (32 days). Ensuring ryegrass growth is kept under control during spring, particularly if N fertiliser is used, may not increase clover content but will at least maintain it. Clover content in pastures following a silage cut, particularly after close cutting (3-4 cm), is generally high, despite herbage levels being very high prior to cutting.

This is because clover is able to adapt to paddocks being closed for silage in spring by forming longer petioles and avoiding shading, provided paddocks are not closed up for too long. Trials at DRC have also shown that lengthening the defoliation interval, or using deferred grazing during dry summers, increased clover content (Harris *et al*. 1997b). Grazing down to a low residual (<1400 kg DM/ha) in summer may lead to high soil surface temperatures, resulting in death of clover plants.

Pests and diseases

Many pests and diseases reduce both yield and persistence of white clover in dairy pastures. These include grass grubs, root invading nematodes, porina caterpillar, clover flea, slugs, fungi such as rust, and the white clover mosaic virus. Root knot (*Meloidogyne* spp.) and clover cyst (*Heterodera trifolli*) nematodes reduce clover yields by 30% and nitrogen fixation by up to 58% with the resulting poor clover performance likely to decrease milk production (Watson *et al.* 1993). Unfortunately, nematodes occur in all soil and while pesticides can control them, it is not economic. Breeding resistance, using gene-transfer technologies, or the introduction of biological control agents, may be the most practical solutions to pest and disease problems, although this does not provide a short-term solution for dairy farmers.

Recently, the clover root weevil (*Sitona lepidus*) has appeared in New Zealand and is potentially a serious pest of white clover. Since its accidental introduction three years ago, the weevil has spread from Waipu Cove in the north to Te Kuiti in the south and Opotiki in the east. The weevil attacks only clovers and shows a preference for white clover over other clover species. Its impact on white clover yields is still unknown. Small weevil larvae feed on root nodules, larger larvae feed on roots, while the adult weevils feed on the foliage. On some dairy farms the weevil has been blamed for the loss of white clover from pastures. Both the larvae and adult weevils are present throughout the year, making management of this pest difficult. As yet there are no known pesticides or biological control agents for use against the weevil. However, healthy clover plants will be more tolerant of insect attack.

Soil moisture content

Low soil moisture levels, particularly in conjunction with high temperatures (>30°C), can have a detrimental effect on clover content (Archer and Robinson 1989). White clover has less drought tolerance than many grass species, due to a shallower root system and poorer water use efficiency. Selection of white clovers with a deeper root system through increased taprootedness has shown some benefit in dryland environments. Clover content of pastures can be maintained or increased during dry periods by irrigation, as demonstrated during dry summers in Northland (Caradus *et al*. 1996).

Conclusion

Both overseas work and New Zealand studies have clearly demonstrated the benefit of white clover for milk production, particularly after peak spring lactation. The goal on any dairy farm should be to increase clover content without compromising annual pasture production, in order to increase milk production. However, the clover content of New Zealand dairy pastures is, on average, considerably lower than the levels needed to significantly increase both the pasture's N economy and feed quality, and hence milk production. A number of factors affect clover growth and persistence in dairy pastures, including climatic conditions, soil N levels, N fertiliser use, soil fertility, companion species, cultivar choice, pasture establishment, grazing management, and pests and diseases. Although the relative impacts of these factors on white clover vary with geographic location and time, all factors need to be addressed in order to achieve increased clover contents. However, most of the options available to farmers will result in only a small, short-term increase in clover content. Options resulting in larger, longer-term increases in clover content are either difficult to achieve (e.g. modifying the preference grazing cows show for clover), have not been tested in a dairy farm system to determine practical and economic viability (e.g. spatially separating ryegrass and clover by using clover as a green-feed crop mainly during summer-autumn), or require further research (e.g. development of a clover cultivar with improved mineral N uptake). In the meantime, it is up to the individual dairy farmer to

assess which management options can be economically used on their own farm to at least maintain or achieve small increases in clover content.

References

Archer, KA and Robinson, GG 1989. The role of stolons and seedlings in the persistence and production of white clover (*Trifolium repens* L. cv Huia) in temperate pastures in the northern Tablelands, New South Wales. Australian Journal of Agricultural Research, *40: 605-616.*

Brereton, AJ, Carton, OT and Conway, A 1985. The effect of grass tiller density on the performance of white clover. Proceedings of the XV International Grassland Congress, *756-757.*

Caradus, JR, Harris, SL and Johnson, RJ 1996a. Increased clover content for increased milk production. Proceedings of the Ruakura Farmers' Conference *48: 42-49*.

Clark, DA and Harris, SL 1995. White clover or nitrogen fertiliser? In: White Clover: New Zealand's Competitive Edge. Agronomy Society of New Zealand and New Zealand Grassland Association Joint Symposium. *pp107-114*.

Edmeades, DC, Pringle, RM, Mansell, GP and Shannon, PW 1984. Effects of lime on pasture production of soils in the North Island of NZ. 1. Introduction and description of the data base. New Zealand Journal of Agricultural Research *27: 349-356*.

Frame, J and Newbould, P 1984. Herbage production from grass/white clover swards. Occasional Symposium of the British Grassland Society *16: 15-35.*

Harris, SL 1994. White clover growth and morphology in dairy pasture in the Waikato region of northern New Zealand. New Zealand Journal of Agricultural Research *37: 487-494.*

Harris, SL and Clark, DA 1996. Effect of high nitrogen fertiliser rates on white clover growth, morphology and nitrogen fixation activity in grazed dairy pasture in northern New Zealand. New Zealand Journal of Agricultural Research *39: 149-158*.

Harris, SL, Clark, DA, Auldist, MJ, Waugh, CD and Laboyrie, PG 1997a. Optimum white clover content for dairy pastures. Proceedings of the New Zealand Grassland Association*. (In press*).

Harris, SL, Waugh, CD, McCabe, RJ and Van Vught, VT 1997b. Deferred grazing during summer increases white clover content in New Zealand dairy pastures. XVIII International Grassland Congress Proceedings *29: 39-40*.

Johnson, RJ and Thomson, NA 1996. Effect of pasture species on milk yield and milk composition. Proceedings of the New Zealand Grassland Association *57: 151-156.*

L'Huillier, PJ 1987. Effect of dairy cattle stocking rate and degree of defoliation on herbage accumulation and quality in ryegrass - white clover pasture. New Zealand Journal of Agricultural Research *30: 149-157*.

Martin, TW 1960. The role of white clover in grassland. Herbage Abstracts *30: 159-164.*

Penning, PD, Parsons, AJ, Orr, RJ, Harvey, A and Campion, RA 1995. Intake and behaviour responses by sheep in different physiological states, when grazing monocultures of grass in white clover. Applied Animal Behaviour Science *45: 63-78*.

Roberts, AHC, Edmeades, DC, O'Connor, MB and Thomson, NA 1991. The importance of fertiliser for milk production. Proceedings of the Ruakura Farmers' Conference *43: 60-65.*

Rogers, GL, Porter, RHD and Robinson, I 1982. Comparison of perennial ryegrass and white clover for milk production. In Macmillan, KL and Taufa, VK, (eds.). Dairy Production from Pasture. Proceedings of New Zealand and Australian Societies of Animal Production. *Pp 213-214.*

Rogers, G and Robinson, L 1984. Whole lactation production of cows grazing white clover or perennial ryegrass. Dairy Production Research Report. Department of Agriculture and Rural Affairs, Australia. *Pp 148-149.*

Schwinning, S and Parsons, AJ 1996. The population dynamics of stoloniferous N-fixing legumes in mixed pasture with grass. Journal of Ecology *(in press).*

Sheldrick, R, Newman, G and Roberts, D 1995. White clover. In: Legumes for Milk and Meat. Chalcombe Publications. *Pp 15-30.*

Thom, ER, Sheath, GW, Bryant, AM and Cox, NR 1986. Renovation of pastures containing paspalum 2. Effects of nitrogen fertiliser on the growth and persistence of overdrilled ryegrass. New Zealand Journal of Agricultural Research *29: 587-598*.

Thomson, DJ 1984. The nutritive value of white clover. In Thomas DJ, (ed.) Forage Legumes. Occasional Symposium of the British Grassland Society *16: 78-92.*

Ulyatt, MJ 1981. The feeding value of herbage: Can it be improved? New Zealand Agricultural Science *15: 200-205.*

Watson, RW, Harris, SL, Bell, NL and Neville, FJ 1993. Pasture pests reduce white clover performance. Proceedings of the Ruakura Farmers' Conference *45: 57-61*.